CONCEPTUAL ESTIMATING WITH BUDGET COST DATA FOR C.M. OF SHUTTLE FACILITIES

"CONCEPTUAL COST ESTIMATING USING KSC BUDGET DATA COST

FOR

CONSTRUCTION MANAGEMENT OF SPACE SHUTTLE FACILITIES

by

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CONCEPTUAL ESTIMATING WITH BUDGET COST DATA FOR C.M. OF KSC SHUTTLE FACILITIES

or

Conceptual Cost Estimating using KSC Budget Cost Data for Facilities Construction and Ground Support Equipment Elements

ABSTRACT

This presentation discusses the use of Kennedy Space Center Technical Report, TR-1508, Budget Cost Data for Facilities Construction and GSE Element, for preparing conceptual, budget, funding, cost estimates and preliminary engineering reports.

This price book, developed since 1974 presently contains over 260 pages of cost data, and is based on actual bid prices and the Government estimates for projects totaling over $230 million. Also included are integrated cost management one-page summaries for (1) project budget line item comparison; (2) labor and materials breakdown for subcontracts with mark-up, and (3) system summary for buildings or systems showing unit prices per 16 CSI divisions, project description, special features, abstract of bids, and square foot costs. The primary feature of this book is the detail labor and material, quantities and unit prices with general and subcontractor and mark-up for commonly used aerospace facility and ground support equipment elements and systems.

Some of the over 200 commonly used elements and systems are tower steel for service structures, steel/aluminum access platforms, mating devices, Solid Rocket Booster Holddown Posts, Payload Changeout Room (PCR) doors, pneumatic remote control panels, PCR bridge hinged column bearing assembly, Halon fire protection systems, stainless steel pipe runs, uninterruptible power systems, Orbiter access platforms, piping and cabling systems and fiber optic cable system.

One of the best methods for making ROMs (rough order of magnitude) conceptual estimates is to find similar items, buildings, systems, elements, already designed, built, and costed and adjust that cost for time, location and current design requirements. With the aid of these unit bid prices, KSC conceptual budget estimates are more accurate and timely. The prices also serve as a rule of thumb and cross-check feedback for detail evaluating designed prices-out project cost estimates.

This technical report, updated annually through 1981, is one of many tools used by KSC Design Engineering to evaluate cost trade-off studies that resulted in cost effective design and construction of KSC Space Shuttle facilities. These facilities are successfully being used to process, checkout launch and recovery elements of the Space Transportation System which assures the United States continued pre-eminence in space exploration and development.

INTRODUCTION

This presentation will describe the Kennedy Space Center (KSC) Price Book, TR-1508, Budget Cost Data for Facilities Construction and Ground Support Equipment (GSE) elements by telling you what it is, its background and purpose. Also, how and why it is being used for conceptual (funding) estimating and as a tool for cross-checking detail labor and material government estimates.

SPACE SHUTTLE ESTIMATING - COST MANAGEMENT BACKGROUND

The concept for the KSC Shuttle facilities was developed in late 60's and early 70's based on limited criteria, horizontal concept, reuse of Apollo facilities, as much as possible and two simultaneous Shuttle-Orbiter flows, was conceptually costed by KSC's Design Engineering March-October 1970.

The conceptual construction cost estimate of facilities was $147,573,000, which included 10% contingencies and 7% S&A. This was further developed and escalated to $297,330,000 and included GSE equipment.

The construction of facilities was budgeted in the early 1970's at $150 million of 1970 dollars. The actual in-place cost through April 1980 was $225.3 million which is about 2% less than the original escalated budgeted amount. Quite a remarkable achievement. Some important scope changes that made this cost management more critical was the added Sound Suppression System and the redesign of the Rotary Service Structure for extra Air Force requirements after bidding LC-39 Pad A (during construction of the foundation).

A summary cost breakdown for the CofF Shuttle:

	Millions
Orbiter Landing Facility	27.3
Orbiter Processing Facility	27.4
Launch Complex 39 Pad A	40.4
Launch Complex 39 Pad B	51.7
Mobile Launcher Platform #1	13.8
Mobile Launcher Platform #2	13.9
Vehicle Assembly Building	23.8
Launch Control Center	2.0
Solid Rocket Booster Disassembly (Hangar AF)	6.2
Parachute Facility	1.7
Hypergol Maintenance Facility	5.3
Launch Equipment Test Facility	2.0
Rehabilitation of Barge Channels	2.1
Construction Emergency Power Facility	2.2
Mods to Crawler Transporter Maintenance Facility	1.3
Shuttle/Carrier Aircraft Mating Facility	1.7
Miscellaneous Modifications	2.5
Sub-total Shuttle	225.3

The successful construction of the KSC Shuttle facilities under budget on schedule is a tribute to the remarkable KSC Design Engineering and construction management team. This is especially noteworthy for a research and development project. Many R&D projects during the 70's were costing two times to three times budgeted costs due to the (1) energy crisis; (2) social, environmental and economical regulations; (3) environmental requirements and concerns; (4) erratic (volatile) economy.

These, and many other problems were solved by fast tracking, detail planning and scheduling, cost and design engineering solutions through an unusual efficient construction management program.

The use of KSC estimating specification to standardize cost estimating formats, the KSC Cost Index, and the KSC Price Book to provide more accurate cost data served as an important cost engineering tool in this unusual challenging effort. (See Construction Bidding Cost of Shuttle Facilities for a more detailed narrative of facilities and construction bids).

See Figure A - KSC Major Facilities Pictorial Baseline.

A little background on the Shuttle Mission Profile starts with prelaunch checkout to horizontal landing, as shown on Figure B, Space Shuttle Mission Profile.

The KSC Price Book was created by Joseph A. Brown, Lead Cost Engineer, in late 1974 as part of TR-1511, "KSC Monthly Facility and GSE Cost Index" to provide rule-of-thumb cost of aerospace facility construction costs, since no such information was available. The October 10, 1974 Cost Index had 21 system unit costs. April 21, 1976 the compilation of the development of 54 budget unit costs were first printed. It was published every six months until October1980, when it became an annual publication. Its most recent publication, December 1981, contained over 260 pages of cost data.

Aerospace construction is similar to building, civil, petro-chemical process industry, construction in that it uses concrete, steel, form work and most conventional materials but it is different and more costly due to its higher reliability requirements, tolerance, and safety requirements because of the hazardous operations, remote controlled fuels and gases and some exotic materials, etc.

Purpose:

The purpose of this Price Book is to

a. Show the compilation of KSC labor and material prices with typical markups.

b. Show the development of rule-of-thumb (ROT) unit prices for aerospace elements and systems.

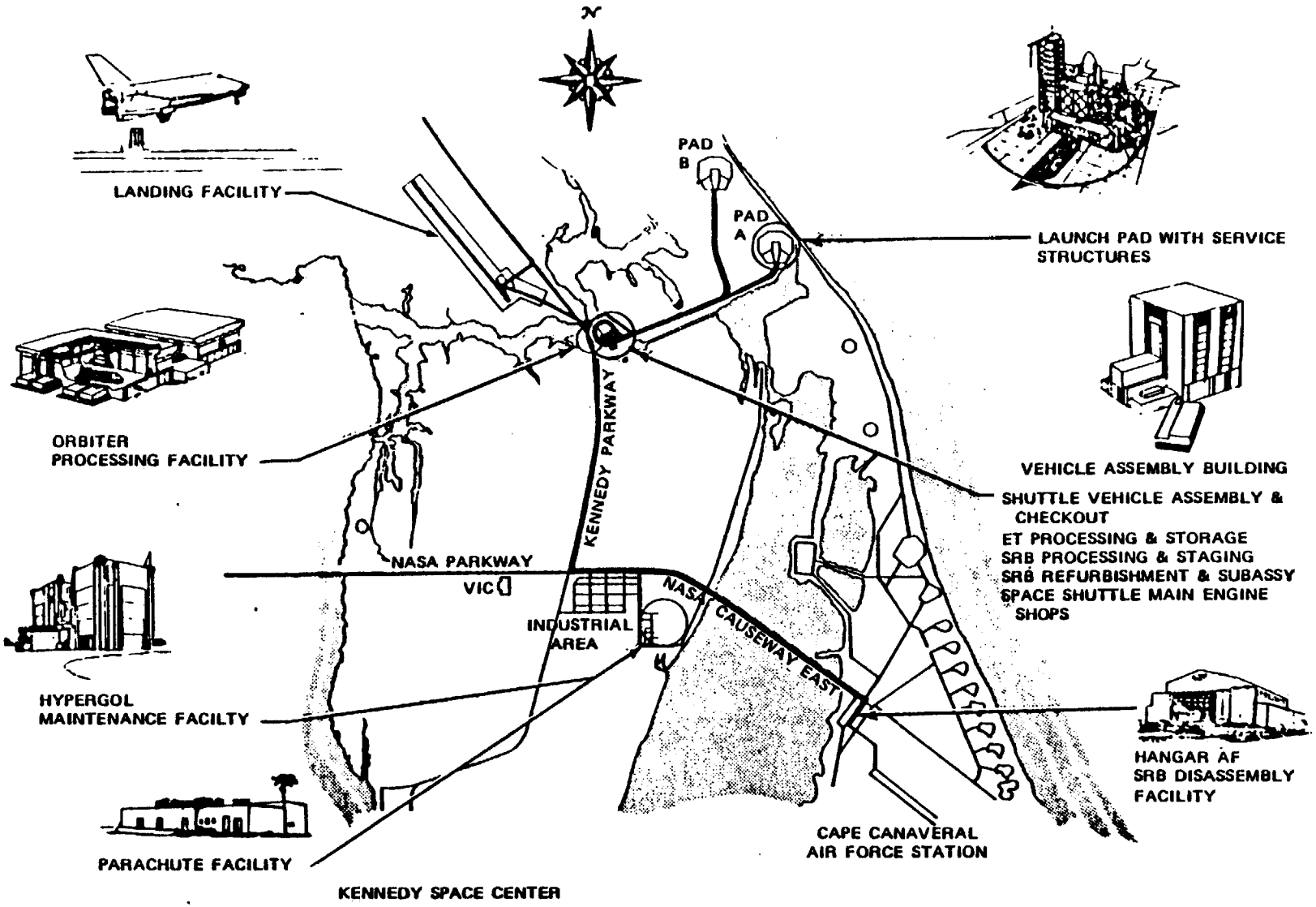
c. Record major projects costs and KSC unique cost engineering experience for conceptual estimates now and future computer data base.

d. Aid in the development of automated conceptual estimating system for aerospace construction and ground support equipment.

e. Aid in cross-checking detail labor and material government estimate for current prices and serve as a checklist of necessary items to prevent omissions.

f. Provide better, more accurate, consistency, and uniform cost estimates in a timely manner now and in the future.

FIGURE A



KSC Major Shuttle Facilities - Pictorial Baseline

BACKGROUND

SPACE SHUTTLE MISSION PROFILE

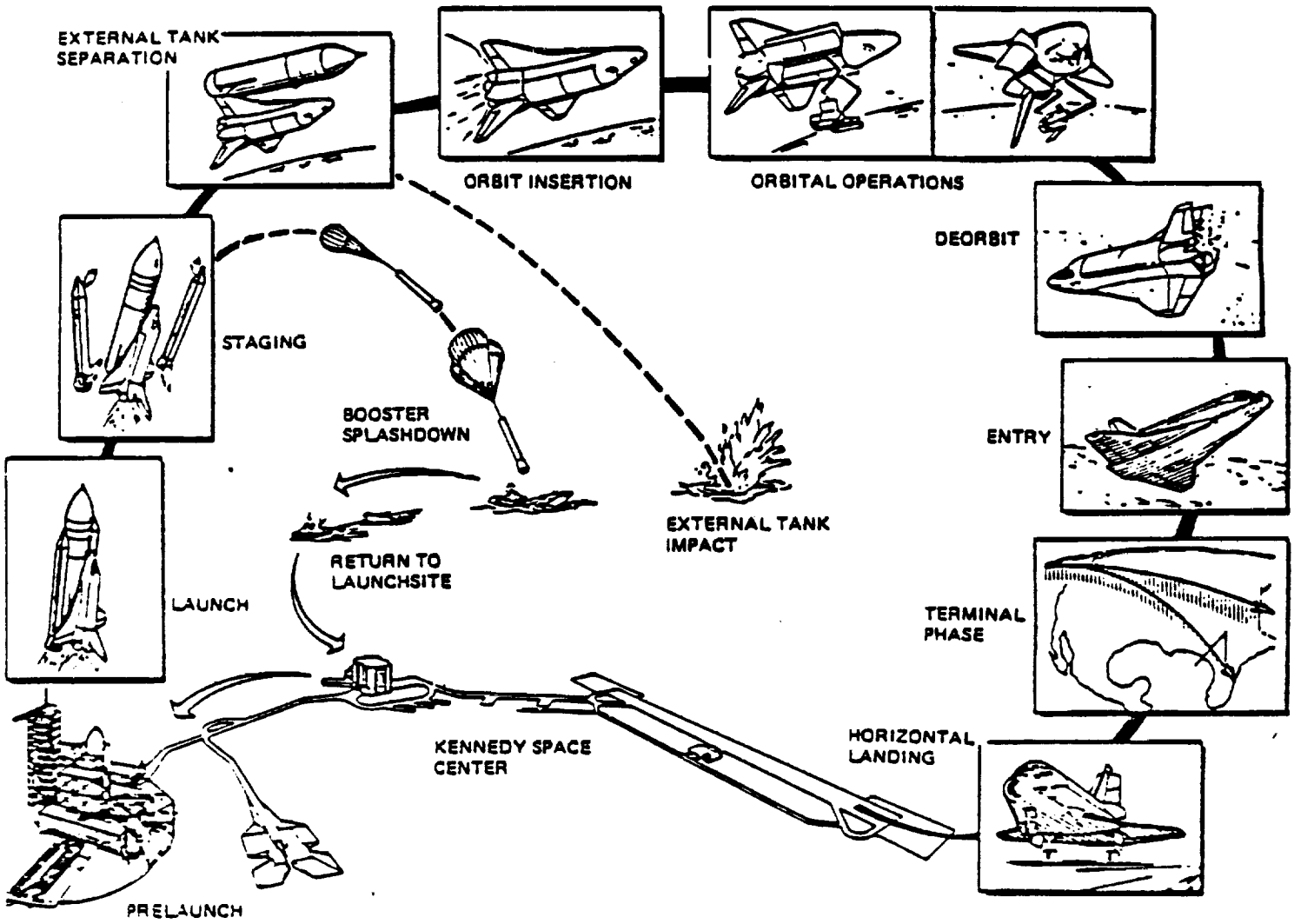


FIGURE B

Why Conceptual Estimates:

Conceptual estimates of KSC facilities and GSE are required to provide the most probable project cost for budget, funding, and project approval purposes. The conceptual estimate is continuously used throughout the project development cycle to compare the further defined detail cost estimate with the approved budget to assure cost control of the project. And finally, the Government bid estimate with detail quantities, labor and materials is evaluated against the budget to assure costs are within budget dollars and can be awarded to the successful bidder.

TR-1508 - What is it?

TR-1508, "Budget Cost Data for Construction and GSE Elements" is a 268 page price book of KSC construction and GSE. It is divided into three basic parts - the first is bid abstracts of major Shuttle projects; the second part is the budget cost data divided into 16 CSI/SPECSINTACT divisions, and the third part is the system summary of 25 typical projects.

Part one lists over 112 major Shuttle projects with the bid date, successful low bid, bidder, and the government estimate for comparison. The total bids of these projects id $217,866,876, which averages 6.6% below the government estimate and shows the position of the government estimate 3.4. of six average bids. (See Figure C for Bids Summary and Sample Format).

In part two, the budget cost data sheets are divided into the 16 CSI/SPECSINTACT divisions with a typical example cost data description for each division.

ivision 1 - Overhead General Conditions - Payroll Tax & Insurance
ivision 2 - Earthwork - Piling and Road Paving System
ivision 3 - Concrete - Concrete Wall Trench System
ivision 4 - Masonry - Concrete Block Wall System
ivision 5 - Metals - Structural Steel Service Structure
ivision 6 - Wood and plastic - Wood stud drywall system
ivision 7 - Thermal and Moisture Protection - Insulated roof deck system
vision 8 - Doors and Windows - Special Hinged Insulated door for PCR
vision 9 - Finishes - Suspended Acoustical Tile system
vision 10 - Specialties - Mesh Partitions
vision 11 - Equipment - laboratory
vision 12 - Furnishing - Carpeting
vision 13 - Special Construction - elevated floor system - PEMB
vision 14 - Conveying System - 125-ton bridge crane-RSS drive trucks
vision 15 - Mechanical - RSS bridge hinge column - PSCL A/C
vision 16 - Electrical - emergency lighting system - fiber optic cable.

t data sheet shows quantities, detail labor and material breakdown for the ost items for each system. It includes the normal contractor markups for ales tax, overhead, profit and bond.

e Figure D, Concrete Walled Trench & Grating.

e Figure E, SRB Holddown Posts - MLP - Example of Casting & Machining Prices

Project, Date and Low Bidder		Low Bid	Gov. Est.	%	Gov. Position/Total Bids
CIX	KSC/SIS Security Mods LCC 4R10 Bid 7/8/81 Butler Const. Co.	235,000	299,354	-21.5	6/7
CX	Payload Fitting Assembly Support Rails & Misc. Hdw. Bid 7/10/81 Crane Research & Eng. Co., Inc.	124,314	185,240	-32.9	4/8
CXI	Orbiter Landing Viewing Site Total Bid 8/5/81 F.A. Kennedy, Inc.	399,894	389,678	+2.6	1/9
CXII	E.T. Hydrogen Vent Sys. Mod/Mod - Common Hardware Bid 8/12/81 Speciality Maint. & Constr., Inc.	434,140	395,519	+9.8	1/8
	TOTAL	217,866,876	233,219,905	-6.6	383 of 671 avg. 3.4 of 6.0

THE LOW BIDDER AVERAGED 6.6% UNDER THE GOVERNMENT ESTIMATE. THE POSITION OF THE GOVERNMENT ESTIMATE AVERAGE OF 3.4 OF 6.0 BIDS FOR 112 PROJECTS.

FIGURE C

TR-1508

TR-1508 (9) TR-1508

☐ GROUND SUPPORT EQUIPMENT — **COST ESTIMATE** — ☐ CONSTRUCTION — 34

CODE	DATE COMPLETED	SHEET / OF
COST INDEX	9-9-80	SHEET 26 OF 191 SHEET 1 OF 5

PROJECT	DRAWING NO(S)	SHEET NO.
CONCRETE WALLED TRENCH*, WITH SUPPORT BLOCKS** & GRATING***		

LOCATION	PCN
50' LONG X 2' WIDE X 2' DEEP	76485

ARCHITECT OR ENGINEER	WORK ORDER OR CONTRACT NO.
	2197

ESTIMATOR	CHECKER	APPROVED
M. Jones	C. Cadra	

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR ($ [redacted]) PER UNIT	LABOR TOTAL ☐ FIELD ☐ FAB.	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
EXCAVATE TRENCH 1/2 HAND	30	CY	17.54	526	1.00	30	
FORMWORK FOR TRENCH	672	SF	1.97	1,324	.90	605	MEANS
FORMWORK FOR 5 SUPPORT BLOCKS	60	SF	1.97	118	90	54	MEANS
#4 REBAR FOR TRENCH 7 #4 X 50'	335	LB	.20	67	.43	144	
#4 REBAR FOR SUPPORT BLOCKS 7 LF@1'-8"	53	LB	.20	11	.43	23	
POUR CONCRETE FOR TRENCH WALLS & FLR.	18	CY	10.00	180	40.00	720	
ANCHOR BOLTS IN SUPPORT BLOCKS	10	EA	3.00	30	.60	6	
ANGLE FRAME SET IN CONCRETE	800	LB	.50	400	.40	320	
FINISH CONCRETE, TOP SURFACE	416	SF	.10	42	.05	21	
CURE CONCRETE TOP SURFACE	416	SF	.03	12	.03	12	
HARDENER, TOP SURFACE	104	SF	.03	3	.05	5	
2" CAST IRON GRATING, 108 S/F 26"W	5,486	LB	.10	549	.52	2,853	*NEENAH 8-5-80
HAUL DIRT AWAY, 3 MILES	24	CY	3.00	72	-		
BACKFILL	6	CY	8.19	49	-	-	
SUBTOTAL				3,383		4,793	
SALES TAX & PT&I		%	28	947	4	192	
SUBTOTAL				4,330		4,985	9315 -
OVERHEAD	15	%					1397 -
SUBTOTAL							10712 -
PROFIT	10	%					1071 -
SUBTOTAL							11,783 -
BOND	1	%					118 -
TOTAL							11,901 -

COST PER LF (50) $238 COST PER CY (18) 661 COST PER SF (108) 110

*NEENAH FOUNDRY - NEENAH, W/S. 414-725-3041 - MIKE RANKIN

2" SOLID C.I. GRATING 26" WIDE - R - 4990-H-26"-2"-24"

108 SF - 50.8 LB SF

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KSC FORM 21-243 (REV. 4/77)

FIGURE D

CONSTRUCTION COST ESTIMATE

CODE: COST INDEX	DATE COMPLETED: 9-5-80	SHEET 25 / 2 OF 191 / 2
PROJECT: CONCRETE FOR 6" SLAB ON GRADE W/THICKENED EDGE		DRAWING NO.
LOCATION		PCN 77406
ARCHITECT OR ENGINEER		WORK ORDER OR CONTRACT NO. 1690
ESTIMATOR: VARNDELL	CHECKER: W. Sitchenia Wf	APPROVED

SUMMARY	QUANTITY		LABOR ($ [redacted]		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	TOTAL	PER UNIT	TOTAL	
EXCAVATION	1	CY	17.54	17.54	--	--	
FINE GRADE	54	SF	.10	5.40	-	--	
POUR CONCRETE	1	CY	10.00	10.00	40.00	40	
FINISH CONCRETE	54	SF	.10	5.40	.05	3	
CURE	54	SF	.03	1.62	.03	2	
HARDEN	54	SF	.03	1.62	.05	3	
EXP. JOINT	10	LF	.20	2.00	.20	2	
BACKFILL	1/3	CY	8.50	2.83	--	--	
3 PLY BU MOPPED VAPOR BARRIER	54	SF	.35	18.90	.15	8	
SUB-TOTAL				65.31		58	
SALES TAX		%			4	2	
TAX & INS.		%	28	18.29			
SUB-TOTAL				83.60		60	144
OVERHEAD	15	%					22
SUB-TOTAL							166
PROFIT	10	%					17
SUB-TOTAL							183
BOND	1	%					2
TOTAL CONCRETE & MISC.							185
COST PER SF (54)							3.43
25							

KSC FORM 21-243 (3/75)

☐ GROUND SUPPORT EQUIPMENT | **COST ESTIMATE** | ☐ CONSTRUCTION

5K

CODE	DATE COMPLETED	SHEET / OF
C100 ANALYSIS	BID 3-14-80	SHEET 51 OF 191

PROJECT	DRAWING NO(S)	SHEET NO.
SRB HOLDOWN POSTS - MLP	79K06811	

LOCATION	PCN
KSC/VAFB	77208

ARCHITECT OR ENGINEER	WORK ORDER OR CONTRACT NO.
PRC	0626 10-0039-0

ESTIMATOR	CHECKER	APPROVED
Thomason PRC 1391	T/L Jones PRC-1391	

79K06811-1
HOLDDOWN POST SUMMARY

	QUANTITY		LABOR (MH)		MATERIAL		LABOR $ COST PER UNIT
	NO. UNITS	UNIT MEAS.	PER UNIT	☐ FIELD ☐ FAB. TOTAL	PER UNIT	TOTAL	
Alloy & Liquidize Steel	41,600	LB	.005	208.0	.30	12,480	.10
Fabricate Mold	1	EA	125.	125.0	500	500	2,500.00
Pour Steel into Mold (8 pours)	41,600	LB	.0055	228.8	.03	1,248	.11
Remove Posts from Mold	8	EA	23.4	187.2	130.	1,040	468.00
Heat Treat w/oil quench	8	EA	31.2	249.6	156.	1,248	624.00
Remove attached half-coupons	24	EA	.75	18.0	30.	720	15.00
and brinnell test							
Tooling for Machining		A/R	375.	375.0	3,750	3,750	7,500.00
Machining the Posts	41,600	LB	.03	1,248.0	.18	7,488	.60
Radiographs (100%)	384	EA	.45	172.8	5.50	2,112	9.00
Template & Bushing for drilling	1	EA	12.00	12.0	450.	450	240.00
Drill 2.875" Ø Base holes	64	EA	5.00	320.0	3.50	224	100.00
Sub Totals				3,144.4		31,260	
Labor Hrs. X Mach. Shop Rate	3,144.4	HR	20.00	62,888			
P.T.&I		%	25	15,722			
				78,610			
Overhead & Freight		%	20	15,722		6,775	
				94,332		38,035	132,367
Profit	10	%					13,237
ECBC	41,600	LB	3.50				145,604
American Western (error)			1.85				76,800
Jesse Engineering			2.55				106,080
Belco Steel (Low Bidder)			3.07				127,520
Craft Machine			3.56				148,300
Speedway			3.82				159,040

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FIGURE E

TR-150P

TR-150X

☐ GROUND SUPPORT EQUIPMENT

COST ESTIMATE

☐ CONSTRUCTION 5K

CODE	DATE COMPLETED	SHEET 52 OF 191 SHEET 1 OF 1
COST INDEX	9-11-80	

PROJECT	DRAWING NO(S)	SHEET NO.
MACHINE STEEL, ROD END		

LOCATION	PCN
	77406

ARCHITECT OR ENGINEER	WORK ORDER OR CONTRACT NO.
	2197-B

ESTIMATOR	CHECKER	APPROVED
M. Jones		

_____SUMMARY	QUANTITY		LABOR ($ [redacted])		MATERIAL		TOTAL COST
	NO. UNITS	UNIT MEAS.	PER UNIT	☐ FIELD TOTAL ☐ FAB.	PER UNIT	TOTAL	
STEEL PLATE 6"X12"X2 1/2" THK	51	LBS	—	—	1.00	51	
MACHINING TIME	1	EA	320	320	—	—	
HEAT TREAT	1	EA	15	15	—	—	
CADMIUM PLATE	1	EA	10	10	—	—	
SUBTOTAL				345		51	
PT&I AND SALES TAX		%	28	97	4	2	
SUBTOTAL				442		53	495
OVERHEAD	15	%					74
SUBTOTAL							569
PROFIT	10	%					57
SUBTOTAL							626
BOND	1	%					6
TOTAL							632
ESCALATION FROM 6/15/77 TO 1-1-80							166
IS 26.31 % (PER COST INDEX)							798
COST PER LB	51	LBS					15.65

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Part three consists of sample cost management summaries for (1) budget line items which shows the budger 30%, 60% and 90% design estimates compared to the final government estimate; (2) a projects labor and materials summary showing a detail breakdown of the architectural/structural, mechanical and electrical costs with contractor's markups shown separately; (3) system summaries broken down into 16 CSI/SPECSINTACT divisions with major quantities and unit prices. This summary also includes project descriptions, design data, scope special features, bidders and bids and estimating comments. Some of the facilities system summaries are for LC-39 Pad B and RSS, Orbiter Mate Devices, HB 2 OPF Platforms, Shuttle Payload Vertical Processing Facility, Crawler-Transporter Maintenance Facility, Life Science Support Facility, etc.

See Figure F for sample of Budget Line Item Summary for MLP #2 Piping & Cabling LC-39.

See Figure G for sample Labor and Material Summary for MLP #2 Piping & Cabling LC-39.

See Figure H for sample system summary for MLP #2 Piping & Cabling LC-39.

CONCEPTUAL ESTIMATING

One of the best methods for making ROMs (rough order of magnitude) conceptual estimates is to find similar items, buildings, systems, elements, already designed, built, and costed and adjust that cost for time, location and current design requirements. With the aid of these unit bid prices, KSC conceptual budget estimates are more accurate and timely. The prices also serve as a rule-of-thumb and cross-check feedback for detial designed prices-out project cost estimates..

In making conceptual estimates it is important to first determine the purpose of the estimate. Next, find a similar project and adjust for time, location, and design or conceptual design and conceptual estimate using conceptual unit prices such as developed in this price book. Next, add for escalation, to the estimated mid-point of construction, contingencies, and supervision and administration doing construction.

The cost of design and/or construction management is usually estimated separately since it is funded separately.

An over-simplification example of estimating the cost of Piping and Cabling for MLP #3 based on the Government Estimate for MLP #2 is:

Government Estimate of $2,209,401 for MLP #2 bid May 24, 1978. (See Figure H).

KSC Cost Index November 1981 $= \frac{3675}{2963} = 1.24$ X $2,209,401 = $2,739,657 estimated
May 1978

Cost November 1981 = round to $2,740,000.

NOTE: The Government Estimate was used in this case since the comment note shows the Government Estimate was very good. It should be noted that the government furnished equipment was not included in this estimate.

COMPARISON OF BUDGETED AND ESTIMATED COSTS

SHEET 5 OF 122

DRAWING NUMBER	SHEETS	PCN	LOCATION	PROJECT
79K11397 / 79K14105	253 3	77173 81764	LC 39 MLP #2	TASK I PIPING & CABLING / TASK II BLAST DECK

BORE ORDER/CONTRACT	ARCHITECT/ENGINEER	ESTIMATOR	CHECKER	CODE	SUBMITTED
2175 IFS 13-3054-8	PRC	Thomason PRC 1391	Farrar PRC 1391	C-100	5-9-78

ESTIMATED COSTS

BUDGETED LINE ITEMS	BUDGETED COSTS	% DIF.	8-26-77 CODE C-30	% DIF.	11-9-77 CODE C-60	% DIF.	1-25-78 CODE C-90	% DIF.	1-27-78 CODE REV. C-90	% DIF.	5-1-78 CODE C-100	% DIF.	5-26-78 CODE C-100 AMEND #1	% DIF.	6/7/78 AMEND #1,2&3 CODE	% DIF.	CODE	REMARKS
STRUCTURAL TASK I			NOT IN EST.		298,530	+11	332,641	-51	164,205	+30	213,902	+1	216,189					
MECHANICAL "			985,544	-13	861,660	+3	884,163	0	884,163	+4	922,089	+7	984,176					
ELECTRICAL "			739,713	+1	749,255	-10	670,999	0	670,999	+23	825,930	-4	792,785					
TASK I SUB TOTAL			1,725,257	+11	1,909,445	-1	1,887,803	-9	1,719,367	+14	1,961,921	+2	1,993,150					
STRUCTURAL TASK II											(6) 98,620	0	98,620					
ECBC WITHOUT SPL. COND.			1,725,257	+11	1,909,445	-1	1,887,803	-9	1,719,367	+20	2,060,541	+2	2,091,770					
SPL. CONDITIONS																		
CONTINGENCIES			345,051	+11	381,889	-51	188,780	-9	171,937									
ESCALATION											111,681	+2	113,374					C-100 ESCALATION 5.42%
ECBC WITH SPL. COND.			2,070,308	+11	2,291,334	-9	2,076,583	-9	1,891,304	+17	2,172,222	+2	2,205,144					
					(1)		(2)		(3)		(4)		(5)					
TOTAL	3,100,000		2,070,308	+11	2,291,334	-9	2,076,583	-9	1,891,304	+15	2,172,222	+2	2,205,144					
PCT. DIFFERENCE, BUDGETED/ESTIMATED TOTALS		-33		-26		-33		-39		-30		-29						

NOTES

1) STRUCTURAL SECTION ADDED TO EST. (2) LABOR RATES INCREASED. ELECTRICAL CHANGE IN SCOPE. (3) WINCHES REMOVED FROM PROJECT. (STRUCT. SECTION)

4) STRUCTURAL STEEL PRICE INCREASE. HALON PIPING ADDED TO MECHANICAL. P.T.&I. AND BURDENS INCREASED FOR ELEC. SECTION. TASK II ADDED TO PROJECT.

5) ELEC. RACKS REMOVED FROM CONTRACT. ECS DUCT REFURB ADDED TO MECH.

(6) PRC ESTIMATE OF $146,000 WAS REDUCED AFTER DD-FED SUGGESTED A RE-EVALUATION BASED ON THE BID OF $99,000 BY BELKO FOR MLP-1.

KSC FORM 21-348 (9/76)

FIGURE F

SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR BUILDINGS

SHEET 3 OF 133

DRAWING NO	SHEETS	PCN	LOCATION	PROJECT
79K1 176/79K11525	1 THRU 134 1 THRU 8	79436/80165	KSC IND. AREA BLDG. M7-1469	SHUTTLE PAYLOAD VERTICAL PROCESSING FACILITY

WORK ORDER CONTRACT	ARCHITECT ENGINEER	ESTIMATOR	CHECKER	CODE / SUBMITTED
2466 IFB #1 - 4 -8	H.J. ROSS ASSOC., MIAMI, FLA. & PRC*	THOMASON PRC-1391	PIERCE PRC-1391	C1 / 4-14-78

CONSTRUCTION COSTS

DIV. TITLE	QTY	UNIT	$ UNIT	$ BSF	TOTAL	DIV. TOTAL
1. GNL. COND.					149,5 8	
(15 %)						
2 SITE WORK		SF	6.54	6.54		129,754
CLR GRUB	1	ACR	1,473	.07	1,473	
DEMOLITION	56	SY	53.71	.15	3,008	
ERTHWK FILL	3,420	CY	5.6	.95	19,163	
PILING						
UTILITIES (S&W)	779	LF	68.78	2.67	53,583	
PAVING (FLEX)	2,695	SY	14.66	1.97	39,522	
OTHER (DEWATERING)	N/A	LF	--	.65	13,005	
3 CONCRETE	300	CY	195.54	2.92		58,662
FMWK 9.93/CY	1,305	SFCA	2.28	.15	2,978	
REBAR 64.83/CY	44,670	LB	.44	.97	19,449	
CON	300	CY	50.84	.76	15,252	
~~EPOXY FLOOR~~ CURE &	4,248	SF	.55	.12	2,341	
OTHER FINISH INT. DEMOLITION	2,765	CF	6.74	.93	18,642	
4 MASONRY	66	SF	3.35	.11		2,211
BLOCK	743	EA	2.89	.11	2,147	
OTHER MORTAR	40	CF	1.60	.01	64	
5 METALS	325	TON		39.22		788,314
STRUC. STL PLATFORMS	316	TON	1,787	28.10	564,711	
JOISTS & DECK	138	SF	2.39	.02	330	
MISC RAIL LADDER, KICK-P	1,751	LF	122.36	10.66	214,248	
~~ALUM~~ MONORAIL	3.4	TON	2,654	.45	9,025	
PLTFMS GRATING	14,184	SF				
6 WOOD PLASTICS						1,373
CARPENTRY HANDRAIL	1,100	BF	1.25	.07	1,373	
7 MOISTURE PROTECT.	2,959	SF	5.24	.77		15,508
WATERPRFNG	515	SF	2.68	.07	1,382	
INSULATION	932	SF	5.96	.28	5,553	
ROOFING WALKWAY	468	SF	1.49	.03	696	
SIDING	1,976	SF	3.73	.37	7,368	
DECK						
SHT MTL PITCH PANS	32	EA	15.01	.03	509	
8 DOORS & GLASS	2,054	SF	52.99	5.42		108,837
DOORS	1	EA	227	.01	227	
SPECIAL DOORS W/FRAMES	182	SF	153.38	1.39	27,916	
GLASS & GLAZING PNEU SEA	1,872	SF	37.99	3.54	71,111	
FINISH HARDWARE DR.	3	SET	314.	.05	942	
OTHER SCREEN	2,014	SF	4.29	.43	8.641	

DIV. TITLE	QTY	UNIT	$ UNIT	$ BSF	TOTAL	DIV. TOTAL
9 FINISHES	51,016	SF	1.68	4.26		85,716
WALL SYS	2,843	SF	.46	.07	1,316	
FLOOR SYS	22,812	SF	2.02	2.29	46,030	
CEILING SYS	2,688	SF	2.42	.32	6,495	
PAINT & COVER EPOXY FOR IRON	22,673	SF	1.22	1.37	27,590	
OTHER INSULATION	1,881	SF	2.28	.21	4,285	
10 SPECIALTIES						7,496
MESH PARTITIONS	1,695	SF	4.42	.37	7,496	
11 EQUIPMENT						
12. FURNISHINGS						
13. SPECIAL CONSTR.						2,958
ELEV FLR SYS	360	SF	8.22	.15	2,958	
OTHER						
14. CONVEYING SYS.						298,846
ELEVS.	1	EA	202,427	10.07	202,427	
CRANES						
HOISTS W/BOOMS	1	EA	96,419	4.8	96,419	
OTHER						
15. MECHANICAL	5,018	LF	103.01	25.72		516,912
PLUMBING	1,035	LF	45.78	2.36	47,386	
FIRE PROTECT	3,983	LF	64.39	12.76	256,464	
VENTILATING	90,000	CFM	.88	3.92	78,842	
HEAT & A/C		TON	13,422	6.68	134,220	
CLN. RM (HEPA)						
16. ELECTRICAL	144,918	LF	5.63	4 .59		815,793
LIGHTING & POWER	25,420	LF	13.43	16.98	341,362	
CABLE & WIRE INST&COMM	72,868	LF	2.35	8.53	171,469	
CONDUIT						
EXTER SVCS.	41,830	LF	4.57	9.52	191,363	
SPCL. SYS. UNINTER PWR						
LPS WIDE BAND CABLE, OTHER PRC*	4,800	LF	23.25	5.55	111,599	
KSC SPCLZD. CONSTR.	3,651	LF	58.86	10.69		214,895
HYPER SYS	38	LF	73.17	1.38	27.	
OBOI SYS VENT & VACUUM	75	LF	353.71	1.32	26,528	
PNEU SYS	3,196	LF	46.34	7.37	148,096	
OTHER GFE FITTINGS	1,851	EA	6.74	.62	12,468	
PROJECT TOTALS						3,047,275

DESCRIPTION

SCOPE (Circle one)	BASIC PLAN (Circle one)	COMMENTS
1. FAIR	A. SQUARE	GFE VALVE
2. AVERAGE	B. RECTANGULAR	124,077
3. GOOD	C. IRREGULAR	
4. COMPLEX	D. VERY IRREGULAR	
5. SOPHISTICATED	E.	

DESIGN DATA

BLDG. TYPE: HANGAR WITH HIGH BAY
CAPACITY: 2,251,200 CF
STRUC. FRAME: STEEL
EXTERIOR WALL: METAL SIDING
HEIGHT: 1 STORIES 112 FT.
GROUND FLOOR AREA: 20,000 SF
TOTAL FLOOR AREA: 20,000 SF
VOLUME: 2,251,200 CF
PERCENT AIR CONDITIONED: 100 % N/A TONS
OTHER:

SPECIAL FEATURES

ELECTRIC FREIGHT ELEVATOR $214,565

CONSTRUCTION BID DATA (IFB 10-0040-8)

TOTAL BLDG. SF: 20,100

ARCH/STRUC.	$ 68.16	/BSF	$ 1,369,921
INTERIOR MECH	$ 36.41	/BSF	$ 731,807
INTERIOR ELEC.	$ 31.07	/BSF	$ 624,430
TOTAL INTERIOR	$ 135.63	/BSF	$ 2,726,158
TOTAL EXTERIOR	$ 15.98	/BSF	$ 321,117
TOTAL CONSTR.	$ 151.61	/BSF	$ 3,047,275
ADDITIONAL: A.	$	/BSF	$
B.	$	/BSF	$
TOTAL PROJECT EST:	$	/BSF	$ 3,230,112

BID DATE: 4-26-78
AWARDED TO: MAYFAIR $ 3,034,115
CONSTRUCTION TIME SPAN: 300 CALENDAR DAYS
NO. OF BIDDERS: 5 POSITION OF GOVT. EST. 3
PERCENT DIFFERENCE, AWARDED BID AND GOVT. EST. -6.1

BIDDERS

MAYFAIR	(L)	$ 3,034,115
WSJ		$ 3,119,000
GOV. EST.		$ 3,230,112
HOLLOWAY		$ 3,261,100
FISHBACK & MOORE	(H)	$ 3,374,000
		$
		$
		$

TR-1508

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FOR OFFICIAL USE ONLY

LABOR AND MATERIAL COST SUMMARY FOR SYSTEMS

SHEET 4 OF 122

DRAWING NO. TYK 11317 / TYKH135 | SHEETS 253 / 3 | PLN T-1736 / 81764 | LOCATION KSC LC-31 MLP #2 | PROJECT TASK I PIPING & CABLING / TASK II BLAST DECK

WORK ORDER CONTRACT 2193 IFB # 10-0057-8 | ARCHITECT ENGINEER PRC | ESTIMATOR [illegible] PRC 1341 | CHECKER [illegible] PRC 1391 | CODE C-100 | SUBMITTED 5-9-78

LINE ITEM	SITE WORK LABOR	SITE WORK MATERIAL	ARCHITECTURAL STRUCTURAL LABOR	ARCHITECTURAL STRUCTURAL MATERIAL	MECHANICAL LABOR	MECHANICAL MATERIAL	ELECTRICAL LABOR	ELECTRICAL MATERIAL	SPECIALIZED CONSTRUCTION LABOR	SPECIALIZED CONSTRUCTION MATERIAL	(1) OTHER LABOR	(1) OTHER MATERIAL	PROJECT TOTALS
SITE WORK											53,195	32,210	226,010
ARCHITECTURAL STRUCTURAL			46,368	94,237									25,534
MECHANICAL													
SYS Coolants					11,692	13,842							9,014
SYS Fire Protection Halon					6,825	2,189							10,143
SYS Water					7,113	3,030							133,037
SYS Cryogenic					42,167	90,870							17,000
SYS Vent					10,602	6,398							151,205
SYS Envir. Control					33,333	117,872							108,379
SYS Hydraulic					53,655	54,724							9,155
SYS Haz. Gases					6,297	2,908							7,505
SYS O_2 Analyzer					6,015	1,290							5,838
SYS Damper Control					2,176	3,662							
ELECTRICAL							9,771	13,300					23,071
SYS Power and Lighting							310,984	124,142					435,126
SYS Instr. & Comm.													
SYS LPS							2,205	12,597					14,802
SYS. UPS							13,452	10,464					23,916
SYS UCS							4,458	1,077					5,535
SYS Halon Cable & Pwr.													
SYS													
SYS													
SYS													
SYS Pneumatics					85,058	87,327							172,385
OTHER Piping Demolition					2,470	670							3,140
SYS. GFE COSTS					—	2,729							2,729
SUBTOTAL, LABOR			46,368		267,353		340,870				53,195		707,784
SUBTOTAL, MATERIAL				94,237		387,511		161,580				32,210	675,558
SALES TAX NONE %			—	—	—	—	—	—			—	—	
P T & I 25 %			11,592		66,838		85,218				13,299		176,947
SUBTOTAL			57,960	94,237	334,191	387,511	426,088	161,580			66,494	32,210	1,560,271
TOTAL			152,197		721,702		587,668				98,704		234,043
CONTR OVHD 15 %			22,830		108,256		88,151				14,806		1,794,314
SUBTOTAL			175,027		829,958		675,819				113,510		179,432
CONTR PROFIT 10 %			17,503		82,996		67,582				11,351		1,973,746
SUBTOTAL			192,530		912,954		743,401				124,861		106,080
PRIME MARKUP 10 %			19,253		—		74,341				12,486		2,079,826
SUBTOTAL			211,783		912,954		817,742				137,347		20,815
BOND 1 %			2,119		9,135		8,188				1,373		2,100,641
TOTAL			213,902		922,089		825,930				138,720		

NOTES (1) TASK II BLAST DECK.

NSC FORM 21-370 (V-78)

FIGURE G.

SYSTEM SUMMARY OF GOVERNMENT ESTIMATE FOR SYSTEMS

SHEET 3 OF 122

DRAWING NO.	SHEETS	PCN	LOCATION	PROJECT
79K11397/79K14105	253/3	79736/81764	KSC LC-39 MLP#2	TASK I / TASK II PIPING & CABLING/BLAST DECK

WORK ORDER CONTRACT	ARCHITECT ENGINEER	ESTIMATOR	CHECKER	CODE / SUBMITTED
2193 IFB#10-0054-8	PRC	Thomason PRC-1391	C. Pierce, PRC-1391	C-100 / 5-9-78

CONSTRUCTION COSTS

A&S TRADES / DIV. TITLE	QTY	UNIT	COSTS $ UNIT	COSTS $ LF	COSTS TOTAL	COSTS DIV. TOTAL	SYS. INVOLVED MECH	SYS. INVOLVED ELEC
1 GNL. COND.						[illegible]		
(15%)					108,955	[illegible]	X	
2 SITE								
CLR GRUB								
DEMOLITION								
ERTHWK FILL								
PILING								
PAVING								
UTILITIES								
OTHER								
3 CONCRETE								
FWRK								
REBAR								
CONCRETE								
4 MASONRY								
5 METALS	86.6	Ton	3,609	4.49		312,522	X	X
STRUCT STL	42.6	Ton	4,404	2.69	187,613			
MACHINED STEEL	89	EA	295	.38	26,289			
TASK II								
BLAST DECK	44	Ton	2,241	1.42	98,620			
6 WOOD PLASTICS								
7 MOISTURE PROTECT								
8 DOORS & GLASS								
9 FINISHES								
PAINTING								
OTHER								
10 SPECIALTIES								
11 EQUIPMENT								
12 FURNISHINGS								
13 SPECIAL CONSTR.								
14 CONVEYING SYS.								
HOISTS								
CRANES								
OTHER								
TOTAL A/S			[illegible]			312,522		

SYSTEMS TRADES / DIV. TITLE	PIPING DUCTING CABLING CONDUIT SIZES	MATL	QTY	UNIT	COSTS $/UNIT	COSTS TOTAL	OTHER $	$ LF	TOTAL	DIV. TOTAL
15. MECHANICAL	1/4 to 14	VAR	25,762	LF	35.79			35.79	[illegible]	922,089
A. PLUMBING	1/2 to 4"	GALV	515	LF	29.57	15,231				
B. HVAC DAMPER CONTROL	1/4"	S/S	175	LF	46.59	8,154				
C. GFE to	1/2"	S/S	9,741	LF	.36	3,487				
D. HALON	1/2 to 2"	STEEL	406	LF	33.73	13,697				
E. COOLANTS	1-1/2"	S/S	216	LF	168.33	36,359				
F. CRYO	2" to 14"	S/S	1,551	LF	118.27	183,444				
G. PNEU	1/4 to 1-1/2	S/S	6,960	LF	35.45	247,416				
H. ECS STRAIGHT SPOOL SECTIONS-GFE	8-	ALUM	430	LF	474.03	203,834				
I. HYDRAULICS	3/4 to 14"	S/S	1,643	LF	94.71	155,609				
J. OTHER VENT	2" to 3"	S/S	619	LF	40.56	25,108				
J1. O_2 Analyzer	3/8"	CU	1,550	LF	7.26	11,254				
J2. HAZ. GAS	1/4 to 3/4"	S/S	881	LF	15.54	13,694				
J3. DEMOLITION	1/4 to 2"	S/S	1,066	LF	4.56	4,802				
16. ELECTRICAL			43,884	LF	18.82			18.82	[illegible]	825,930
A. EXTER SVCS										
B. POWER	3/4 to 3	GALV COND	3,341	LF	10.73	35,858				
B1. UPS	2-1/2	GALV COND	100	KVA	215.78	21,578				
B2.										
B3.										
C. LIGHTING										
D. INSTRUMENTATION										
D1. CABLE/WB/SW/TAC	16-20 AWG	CU	38,405	LF	18.77	720,808				
D2. UCS	60 COND.	CU	1,868	LF	20.52	38,939				
D3.										
D4.										
E. COMMUNICATIONS										
E1. OIS/PO/PA/TD&SA										
E2.										
F. OTHER										
F1. HALON CONTROLS	14 AWG	Cu	270	LF	34.62	9,347				
F2.										
F3.										
ARCH/STRUCT							312,522	4.49		312,522
TOTAL SYSTEMS	[illegible]					1,748,019	312,522	[illegible]		2,060,541

DESCRIPTION

SCOPE (circle one)	BASIC PLAN (circle one)	COMMENTS
1. FAIR	A. SQUARE	Hoists - NIC
2. AVERAGE	B. RECTANGULAR	Sound Suppression-NIC
3. GOOD	C. IRREGULAR	Halon System-Added
4. COMPLEX	D. VRY IRREG.	Blast Deck-Added
5. SOPHIST	E.	Very Good Gov. Estimate

DESIGN DATA

TYPE FAC: All Steel Structure AREA: 21,014
CAPACITY: 158' x 133' x 25' 3 levels
HEIGHT: 3 STORIES: 25 FT
STRUCT. FRAME: steel
VOLUME: 525,350 CF

SPECIAL FEATURES

GFE MTL. VALUE, MECH. 1,091,193
GFE MTL. VALUE, ELEC. 213,031
BLAST DECK WITH BENCH MARKS.
ECS DUCTWORK SYSTEM

BIDDER	TASK I	TASK II	TOTAL
BLAIR	1,885,500	135,500	2,021,000
GOV'T.	2,104,807	104,594	2,209,401
MAYFAIR	2,176,093	175,118	2,351,211
W&J	2,235,780	133,000	2,368,780
HOLLOWAY	2,313,000	161,000	2,474,000

CONSTRUCTION BID DATA (IFB 10-0054-8)

MECH. LF:	25,762	$35.79 /LF	$922,089
ELEC. LF:	43,884	$18.82 /LF	$825,930
SUBTOT LF	69,646	$25.10 /LF	$1,748,019
OTHER A/STR.	86.6 tn	$4.49 /LF	$312,522
SUBTOTAL	$98.06 /BSF	$29.59 /LF	$2,060,541

SPECIAL COST FEATURES

HAZARDS: AMENDS. #1	$.45 /LF	$	31,229
FAB/TEST/CLN/CERT: #2	$.06 /LF	$	4,039
GFE:	$ /LF	$	
OTHER: SPL. CONDITIONS	$1.63 /LF	$	113,592
SUBTOTAL:	$2.14 /LF	$	148,860
TTL PROJ.	$105.14 /BSF	$31.72 /LF	$2,209,401

BID DATE: 5-24-78
AWARDED TO: ALGERNON BLAIR $2,021,000
CONSTRUCT. TIME SPAN: CAL. DAYS: 210
NO. OF BIDS: 5 GOVT EST. POS: 2 of 5
PCT DIF, AWARDED BID & GOVT. EST: -8.5%

BIDDERS

	(L)	
ALGERNON BLAIR		$2,021,000
MAYFAIR CONST.		$2,351,211
W&J CONST.		$2,368,780
HOLLOWAY		$2,474,000
		$
		$
GOV. ESTIMATE	(H)	$2,209,401
		$

KSC FORM 21-372 (8/76)

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FIGURE H.

CONCLUSION

This technical report, updated annually through 1981, is one of many tools used by KSC Design Engineering to evaluate cost trade-off studies that resulted in cost effective design and construction of KSC Space Shuttle facilities. These facilities are being used successfully to process, checkout, launch and recover elements of the Space Transportation System which assures the United States continued pre-eminence in space exploration and development.

REFERENCES:

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3. KSC Technical Report, TR-1508, Budget Cost Data for Facilities Construction Elements, December 21, 1981.

4. KSC Technical Report, TR-1511, KSC Monthly Facility Construction Cost Index, December 22, 1981.

5. Brown, Joseph A., "Conceptual Cost Estimating using KSC Cost Index for Construction Management" presented at the 24th Annual AACE Meeting, Washington D.C., July 5-9, 1980.

6. KSC/DD-FED Abstracts of Bids Costs, January 1, 1974 to November 1, 1981, dated November 9, 1981.

7. Brown, Joseph A., "KSC Estimating Format for Construction Management" presented at the AACE 21st Annual Meeting, Milwaukee, Wisconsin, June 26-29, 1977.

8. Space Transportation System - Facilities & Operations, KSC-K-STS-MO-1, Appx. A.

9. Brown, Joseph A., "How to Sharpen Your Bidding thru Plan Reading, Cost Estimating, Cost Engineering and Construction Management" estimating workbooks, Vol. I and Vol. II.

10. Department of Energy Study R-2481, by Rand Corporation, "Cost Growth in Pioneer Energy Process Plants in Constant Dollars."

11. KSC Design Engineering Study of Cost Estimating for Horizontal Concept - Locations - Ideal, KSC, White Sands, Western Test Range, Edwards AFB and Wendover AFB, dated October 1970.

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Design Engineering Directorate, DD-FED
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SUBJECT: Conceptual Estimating with Budget Cost Data for C.M. of KSC Shuttle Facilities

Mr. Joseph A. Brown is employed as a Lead Cost Engineer for the National Aeronautics & Space Administration's Design Engineering Directorate. He prepares and reviews Government and contractor's construction and GSE cost estimates amounting to over $2.5 billion for design, fabrication and construction. He is currently working on facility costs and requirements for future space exploration of such programs as the Space Station and Space Shuttle. Mr. Brown received his formal education at the University of Florida. His major study was Architectural and Structural Design, Estimating, Management, Supervision, and Methods and Materials where he received a "BBC" Degree. Mr. Brown has completed courses in Management, Procurement, Contract Cost, and NASA PERT. He received a State and County license for Construction Cost Engineering July 1968. He has done consulting, estimating, and bidding for general and subcontractors for commercial, industrial, and residential complex developers-builders, covering Florida, Georgia, Alabama, New Mexico and California, and Walt Disney World's Contemporary Resort Hotel. He is the Past President and Charter Member of the Florida section of American Association of Cost Engineers; AACE 1969 "Member of the Moment;" General Arrangements Chairman 1975 Annual AACE Meeting; SAME Canaveral Post's "Engineer of the Year," and NASA/Kennedy Space Center's "Federal Employee of the Year."On September 14, 1976, he became the first CCE in Florida. He has written an Estimating Workbook, "How to Sharpen your Bidding," and is writing "Estimation of Construction Costs and Cost Engineering." He has published many technical papers including "Cost Escalation and Labor Productivity, What we can do About it;" "How does the Low Bidder Get Low - and Make Money?" "Construction Cost Control - After Bidding;" and "Bid Cost of Shuttle Facilities." He has conducted Construction Estimating and Cost Engineering Seminars from Miami to Toronto.